

Next Generation Internet (NGI) Implementation to Serve Visible Human Datasets Phase II: Development of Test-Beds

In the NLM NGI project, the University of Michigan (UM) Visible Human (VH) Project team developed a Next Generation Internet (NGI) production system to serve visible human datasets in novel and educationally useful ways; these included a comprehensive set of interactive 2D and 3D VH browsers, featuring arbitrary 2D cutting and 3D visualizations. An interactive WWW navigation engine was deployed to create and visualize anatomic flythroughs, under haptic control of the user, and also to deliver flythroughs developed by expert anatomists in concert with clinicians. Anatomical labels enhanced these visualization sequences and enabled real-time links with appropriate anatomical content resources on the WWW using XML. As such, the UM NGI VH system complemented and extended currently deployed passive WWW information systems with active computational services. This allowed for the delivery of several simultaneous high quality digital streams, creating structured medical knowledge using the VH datasets. NGI test-bed stakeholders included the UM Gross Anatomy Program and the UM Nursing School. A forty station I2 demonstration into a gross anatomy test-bed laboratory was accomplished in partnership with project subcontractor Pittsburg Supercomputing Center (PSC).

In the work done by the UM and PSC group so far, an experienced evaluation team continually respecified and focused the test-bed deployments, as well as measured performance and educational effectiveness of the system. Several peer-reviewed publications resulted from this work. Networking experts provided NGI connectivity and evaluated NGI successes and failures, which also resulted in over 5 peer-reviewed publications. The team also developed an NGI VH data server along with the necessary software. A stable and scalable production system for Phase III deployment in suitable 7x24 UM production facilities has been created.

In the final demonstration to the NLM, the University of Michigan team showed many of the features of the Visible Human software and datasets. The following is a list of deliverables promised in the original proposal and provided by the UM VH team:

- Demonstration and Use of VH Data for 40 Simultaneous Users in UM Gross Labs Using NGI from PSC. Infrastructure scales to 1000's of simultaneous users.
- 3 Working UM/PSC NGI Navigators and Several Browsers Now available for download and/or remote use. Products interact with Visible Human Surface and Labels databases.
 - UM Edgewarp 3.4.x (LINUX/MAC, PC running under Linux kernel)
 - UM iVoxel Browser 2.0 (Mono and Stereo, PC and Mac)
 - PSC Volume Browser (Platform Independent)
 - UM Regional Browsers (with Registered MRI and CT Data)
 - Working NGI Server Infrastructure at UMich and PSC with VH Content, DB, Compute Servers and Content Creation Tools
 - ~400 Segmented and Labeled VHF Structures Labeled with Controlled Vocabulary and queriable using Rosse's Foundational Model of Anatomy (FMA)
- Integrated and demonstrated NCAR/PSC Web100 software was used to measure End-to-End I2 network performance and tune testbed sites and servers. End-to-end performance of over 5mbit/sec was standard.
- Gross Anatomy and Nursing Test-beds Established for Further Collaborative

Development and Study

- 5 Major National/International Demonstrations (2 NASA NREN, iGrid 2002, Internet2 national meeting, University of Hong Kong Nursing School)
- At least 10 Peer Reviewed Publications and >50 Abstracts
- 2 Ph.D. Dissertations (1 in Computer Science and 1 in Education) nearly completed.

The NGI software developed in this NLM program to view the Visible Human datasets has some unique and useful features. The following describes some of the features that were shown in the final NLM reverse site-visit demonstration:

Edgewarp V 3.26.

1. A programmable 3D window displays an image of VHF segmented surfaces, labeled curves, landmark points, and a section plane, all tumbling under joint program/user control. The "filmstrip" script, which permits either Lagrangian (world-based) or Eulerian (section-based) coordinates, moves a section plane continuously while surfaces are turned on or off to maximize the informativeness of the resulting renderings with a global view 2D window also present.
2. Extended facilities for surface data structures using a pair of built-in thin-plate splines. These splines permit the direct visualization of shape changes as surfaces and surface deformations. Multiple specimens can be viewed in deformed and undeformed geometries, as well as in both 3D rendering and in a freely tumbling 2D section. The corresponding spline deformation engines can be viewed by their action on arbitrary grids.
3. Mapping VHF to the single case with a "linked navigation capability" that permits navigations in one labeled volume to be rendered dynamically in the unrelated voxel geometry of any other specimen. Section planes navigate both volumes simultaneously under the control of a shared deformation function (a thin-plate spline).

PSC Volume Browser:

An interactive contour creation, labeling, segmentation, and viewing tool created by the Pittsburgh Supercomputing Center that displays surfaces and contour sets was shown. A version was implemented on Apple platforms for first-year medical gross anatomy courses and used in conjunction with web-based laboratory teaching materials.

Web100 Project

The NCAR/PSC Web100 network diagnostic and tuning tools were used to assess network performance and indicate the occurrence of potential transport bottlenecks.

iVoxel Browser.

iVoxel's "Volume View" module displays volume rendered datasets in monoscopic or stereoscopic scenes with modifiable colormaps and up to three arbitrary, user-controlled clip planes. The "Image View" module renders slices through the Visible Human datasets at any point, in any orientation, and at any scale from 1% - 600%. Data are interactively requested from a server in multiple resolutions, stored locally, and are displayed using the highest resolution cached, with dynamic fill-ins as higher resolution data becomes available. The module tunes to the network using a latency driven heuristic. Anatomical labels, landmarks, and views may be imported and displayed, or created, updated and stored. Web pages may be associated with labels. Labels may also serve as an entry point into the UMLS, as was demonstrated.